Chapter 10
ANALYTICAL TOOLS AND MODEL ASSUMPTIONS

ANALYTICAL TOOLS

A part of the water supply planning effort it is necessary to gain insight into the reaction of the natural system to the projected future water uses. There are several tools available to assist in performing this analysis. The type of tool selected is a result of the complexity of the natural system and the amount of information available to complete the analysis. In considering the complexity of the Central Florida geology and the information available, the most typical approach of assessing ground water conditions has been through the use of computer assisted models. Ground water models provide a means of simulating real world conditions using mathematical equations which describe the physical processes that occur in that system.

The analytical tools used in the development of this plan include ground water models, surface water management assessments, vulnerability mapping and a simple comparative presumptive analysis. Ground water flow models developed for this plan were used to simulate the effects of projected 2020 water demands on the environment and ground water sources in the Kissimmee Basin (KB) Planning Area. A surface water management assessment was made to focus on the management issues associated with the Lake Istokpoga and Indian Prairie Canal system that supply agricultural uses in that area. Vulnerability mapping was used to identify areas where the potential is greatest for future harm to wetlands from ground water withdrawals. Where data was the least available to complete a rigorous analysis, a comparative evaluation was performed to determine of possible movement of poor quality water and the increased potential for sinkhole occurrence. The following sections present the approach taken in evaluating the possible impacts from the projected future water use.

USE OF GROUND WATER MODELS

There are several tools available to help assess the movement of ground water within an aquifer system. A common method of characterizing these flow conditions is through the application of computer models. Most of these models have in common the idea of applying a programming code to solve a mathematical equation defining the movement of water in a porous media. The more popular models are well documented and have Windows based software developed for ease of use. The most popular of these ground water flow models is the U.S. Geological Survey (USGS) Modular Three-Dimensional Finite-Difference Ground Water Flow Model (MODFLOW) code (McDonald and Harbaugh, 1988). This is a well-documented modeling code that has previously been used by the District, USGS and other outside consultants. The SFWMD, USGS, St. Johns River Water Management District (SJRWMD), and Southwest Florida Water Management District (SWFWMD) are all active in the evaluation of ground water resources in Central Florida. Each of their efforts are discussed in the following sections.

SFWMD Modeling Approach

In an effort to assess the ground water conditions within the KB Planning Area, three MODFLOW models were used. Two of these models were developed by SFWMD staff and include the Osceola County model and the Glades, Okeechobee, Highlands (GOH) County model. The third model used in the evaluation was a model developed under contract with the USGS and in conjunction with the SJRWMD and SFWMD. This model focuses on Orange County and the surrounding metropolitan Orlando area. The aerial relationship of these three models is shown in **Figure 19**. In addition to these three models, efforts were made to compare the results of these models with the modeling efforts being made by the SJRWMD and SWFWMD where their respective work overlapped portions of the KB Planning Area. Efforts were made to ensure the information used in these models is consistent as possible.

Osceola County Model

The Osceola County model was developed as a conceptual model focusing on the Upper Floridan aquifer in Osceola County. This model uses the MODFLOW code to create a steady-state simulation of the movement of the ground water within the Floridan aquifer and the surrounding aquifer systems. It contains five layers representing the surficial aquifer, intermediate confining units and the upper, middle and lower sections of the Floridan Aquifer System (FAS). In this model, the surficial aquifer is maintained at a fixed elevation. The elevation is set at what is believed to be the average water table condition for 1995. This was done primarily because of limitations on data for the surficial aquifer and leakance to the underlying aquifers. The remaining layers are all free to fluctuate in response to the natural stresses of the system. The model was calibrated to observed field conditions for 1995. The model is believed to be well calibrated for the Upper Floridan aquifer and reasonably calibrated for the intermediate confining unit, and the middle and Lower Floridan aquifers. Fewer measurements and aquifer test parameters are available for the intermediate and Lower Floridan aquifer layers of the model and therefore less effort was placed on calibrating these layers. In those areas where the model domain extends beyond the boundary of the KB Planning Area, cooperation was sought from the other water management districts in determining the hydrology and water use patterns within their boundaries. An estimated 6,000 water use withdrawals were included within the model. A detailed report of the modeling effort is included in Appendix H.

After initial construction of the model, a calibration process of adjusting the parameters with the model to match responses of the physical system was completed. A trial and error method was applied in calibration of this model. In order to measure the success of the calibration, the model results were compared to the actual water levels obtained from the monitoring well network. The monitoring network of 53 wells were distributed throughout the study area. Layer 3, the Upper Floridan aquifer, was the focus of calibration. Three success criteria were used to measure the steady-state calibration. These criteria included a standard deviation from the averaged water level, simulated level within the range of measured values, and a simulated level within one foot of the averaged measured level. The details of the calibration process are found in the model report included in Appendix H.

Upon satisfactory calibration of the model, the 1995 water use information was revised to reflect the 2020 average and 2020 (1-in-10) drought water use conditions. For an explanation of how the 1995 and 2020 water use estimates were developed, the reader is referenced to Appendix F. The results of these simulations were then compared to those of the calibration simulations to determine the projected change in the water levels in the Upper Floridan aquifer. The projected change in Floridan aquifer levels were then used in the evaluation of the identified resource constraints. The results of these efforts are discussed further in Chapter 4 of this report.

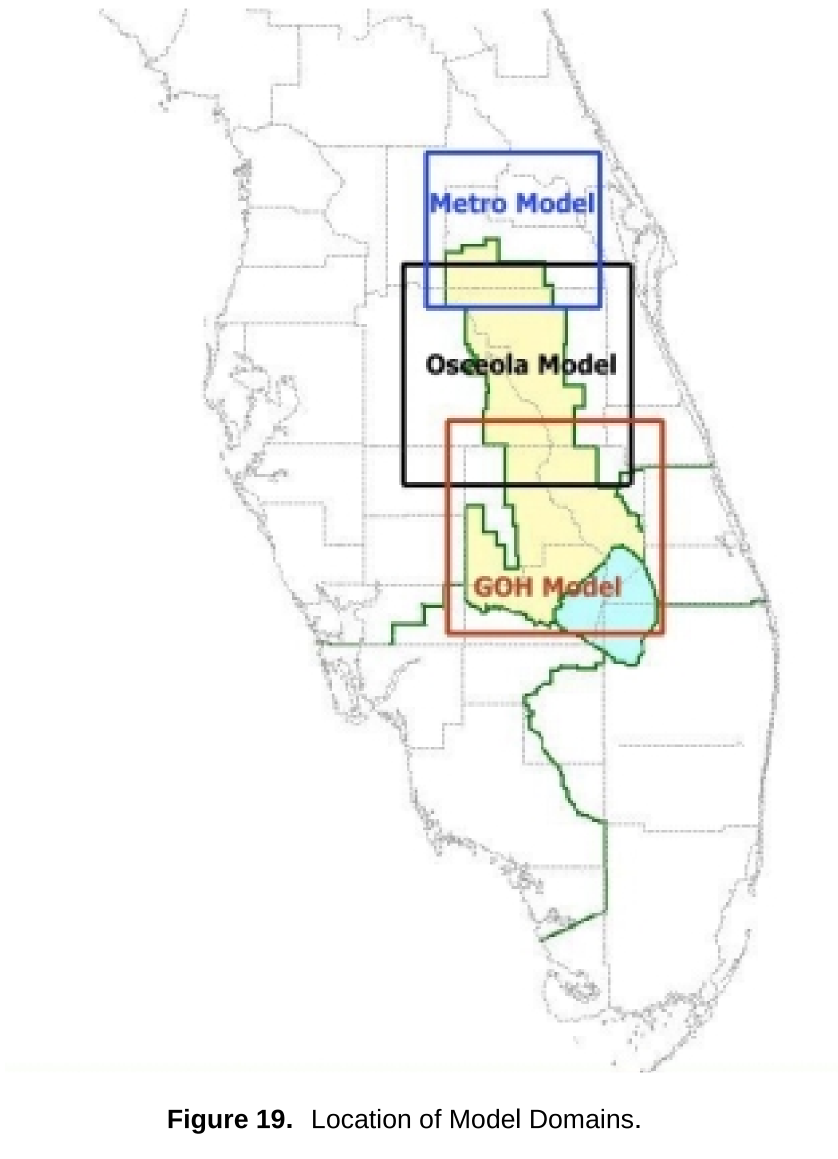

Figure 19. Location of Model Domains.

GOH Model

The Glades, Okeechobee, Highlands (GOH) County model is the second model developed by District staff to address ground water flow conditions in the KB Planning Area. This model covers Okeechobee and Highlands counties, most of Glades County, as well as portions of Charlotte, Martin, and St. Lucie counties. The extent of the model domain can be seen in **Figure 19**. The GOH model uses the MODFLOW code to create a steady-state simulation of the ground water conditions observed in this area. Similar to the Osceola County model, the GOH model contains five layers representing the surficial aquifer, intermediate confining units and the upper, middle, and lower sections of the FAS. In this model, the surficial aquifer and the Lower Floridan aquifers are maintained at a fixed elevation as determined from the average 1995 observed conditions. This was done primarily because of limitations on data for the surficial aquifer and the belief that the connection between the surficial and underlying aquifers is poor. The remaining layers are all free to fluctuate is response to natural systems stresses. The model was calibrated to observed field conditions for 1995. It is believed to be well calibrated for the Upper Floridan aquifer and reasonably calibrated for the intermediate confining unit, and the Middle Floridan aquifer. Fewer measurements and aquifer test parameters are available for the intermediate and middle Floridan layers of the model and therefore less effort was placed on calibrating these layers. In those areas where the model domain extends beyond the boundary of the KB Planning Area, cooperation was sought from the other water management districts in determining the hydrology and water use patterns within their district. An estimated 5,000 water use withdrawals were included within this model.

After initial construction of the model, a calibration process of adjusting the parameters with the model to match responses of the physical system was completed. A trial and error method was applied in calibration of this model. In order to measure the success of the calibration, the model results were compared to the actual water levels obtained from the monitoring well network. The monitoring network of 53 wells were distributed throughout the study area. Layer 3, the Upper Floridan aquifer, was the focus of calibration. Three success criteria were used to measure the steady-state calibration. These criteria included a standard deviation from the averaged water level, simulated level within the range of measured values, and a simulated level within one foot of the averaged measured level. The details of the calibration process are found in Appendix H.

Upon satisfactory calibration of the model, the 1995 water use information in the model was revised to reflect the 2020 average and 2020 (1-in-10) drought water use conditions. The results of these simulations were then compared to those of the calibration simulations to determine the projected change in the water levels of the upper Floridan system.

USGS Model

In 1996, the USGS completed work on a MODFLOW simulation of the hydrologic conditions of the greater Orlando metropolitan area (Murray and Halford, 1996). This work was completed in cooperation with the SJRWMD and SFWMD. This model is often referenced to as the Orlando Metro model. The location of the model domain is shown in

Figure 19. This model simulated the effects of increased ground water use from 1988 to 2010 on the Upper and Lower Floridan aquifers. In 1997, the USGS began updating its previous work by providing an additional calibration period for 1995 and revising its future water use information to reflect estimated ground water use for the year 2020. Additional steady-state simulations for water use during wet and dry periods were also made in an attempt to bracket the projected water level changes from the 1995 average conditions. The Metro model was used in the KB Water Supply Plan evaluation to assist in quantifying the reduction of spring discharges in northern Orange County due to the projected 2020 withdrawals occurring in both the SJWMD and SFWMD, and to provide additional insight on the potential movement of saline water in the eastern portion of the county.

SJRWMD Model

The SJRWMD has worked several years to develop and improve the East Central Florida regional ground water flow model to cover portions of Lake, Orange, Osceola, Seminole, and Polk counties. This model was originally developed for the agency's preparation of the Water Supply Needs and Sources Assessment (SJRWMD, 1994). More recently, the model was updated to address water use conditions consistent with the year 2020 as part of SJRWMD water supply planning effort. The model represents the most advanced effort made to date in simulating ground water conditions in Central Florida. The model domain for the SJRWMD model includes portions of the KB Planning Area north of Lake Kissimmee in Osceola County. A cooperative effort in the development of this model assures that the geologic data and water use information used in the model is consistent with the information used to develop the Osceola County model in areas where the two models overlap. The East Central Florida model was used to compare to the results derived from the efforts completed as part of SFWMD planning effort.

GROUND WATER MODELING PROCESS

The modeling effort simulates ground water conditions within the planning region. This is the foundation upon which the evaluation of resource protection criteria are made. The results of the vulnerability mapping, saltwater movement, and sinkhole analysis all incorporate the results of the projected change in water levels in the Upper Floridan aquifer between 1995 and 2020. The following discussion covers the basic assumptions and processes incorporated into the models developed by the SFWMD staff and the subsequent analyses that used the results of these ground water simulations. The specifics on model construction are presented in Appendix H. For the assumptions used in the USGS and SJRWMD modeling efforts, we direct the reader to the references cited in this plan.

Model Assumptions

Ground water models in general are calibrated by matching computed responses to observed conditions in the natural system. The calibration process involves altering initially estimated model parameters to match, as closely as possible, observed field measurements. The level of calibration, and thereby the ability to accurately predict future conditions, is highly dependant upon the amount of information available for use to construct and calibrate the model. Although models can be loosely or tightly calibrated based upon the available field information, all models that are reasonably calibrated can provide some insight into the hydrologic conditions they are attempting to simulate. The following sections discuss how models handle certain hydrologic input and how this may affect the results of the simulations.

Aquifer Recharge

Recharge to the aquifer is defined in this document as recharge to the FAS. In terms of the modeling effort, this water is derived from leakage from the overlying and underlying aquifers, lateral inflow from the edges of the model, and the direct recharge from drainage wells. Recharge is a positive value where the infiltration of water is into the FAS. Recharge can also be a negative value where water is being discharged from the aquifer. These discharge areas occur where the water levels in the Floridan are elevated above those of the water table. This is the case along the eastern edge of the Lake Wales Ridge and in the southernmost portion of the KB Planning Area. Recharge is a parameter that the model results can be very sensitive to and is difficult to measure in the field. In the case of the Osceola and GOH county models, recharge has been dealt with as a “background” calibration parameter since no direct measurements are available. The resultant recharge/discharge distribution pattern determined from the calibration process compared well with previously published recharge maps produced by the USGS for the KB Planning Area.

In the predictive simulations completed for the year 2020 withdrawals, recharge to the Floridan aquifer is allowed to fluctuate based upon the changing head difference between the intermediate confining unit and Floridan aquifer layers. As the elevation of the water levels in these aquifers are lowered due to increased water use, the amount of recharge is increased due to increased difference in head between the fixed water table and intermediate confining unit head conditions. In those areas where the anticipated change in aquifer levels is predicted to be small, this is a reasonable assumption for the model. In those areas where the change in water levels becomes large, this assumption can lead to under estimating the amount of water level change in the Floridan aquifer that is expected to occur.

In addition to recharge related to climatic conditions, other man-made additions to recharge also occur in the region. Examples of these include the application of treated wastewater to infiltration ponds and recharge related to excess irrigation. These additional factors were addressed through the calibration process for 1995, but not addressed is the future expansion of wastewater systems or increases in recharge due to additional irrigated acreage. These factors may work to moderate the extent of areas identified as vulnerable to wetland harm or to reduce the severity of the changes in aquifer levels in the Floridan aquifer. There effect, however, is likely limited to areas surrounding the point of water application.

Evapotranspiration

Evapotranspiration (ET), the loss of water through evaporation and the uptake in plants (transpiration), is controlled in part by the elevation of the water table. ET is not considered in the construction of the Osceloa and GOH county models, as each of these models contain fixed water table aquifers, eliminating the need to address this parameter. ET is given consideration in the calculation of the water use estimates that are included in the models.

Water Well Withdrawals

Water use assessments and the associated water well withdrawals were made for five use categories including: public supply, agriculture, recreational, commercial/ industrial and landscape irrigation type uses. A total exceeding 11,000 wells was used in modeling the basin. A discussion of the demand projections and projection methodology for withdraws occurring within the SFWMD are provided in Chapter 6 and Appendix F.

Although every effort was made to accurately estimate the 1995 water use and project 2020 water use pattern, there is inherently some error. In particular, the projection of the water use over the next 20 years is based upon historic trends that may change in the future and thereby alter the estimate or distribution of use. The estimates of water use are thought to be reasonable, but represent sources of error in the modeling effort.

Water use estimates from the SJRWMD and SWFMWD were also incorporated into the modeling effort where the model domains encompassed portions of the respective districts. For the SJRWMD, water use estimates for 1995 and 2020 were obtained from their staff and are consistent with the estimates used in the SJRWMD planning process. This water use information represents actual public water supply use and permitted urban type uses (other than PWS) and agriculture for uses greater than 100,000 GPD. The water use information for the SWFWMD was collected only for 1995. This information came from their Annual Water Use Survey. SWFWMD estimates that over 70 percent of the water use in their District is monitored. The remaining use is estimated based upon similar uses in the basin and permitted acreage. Only 1995 use information was used to represent the SWFWMD withdraws in order to be consistent with their effort to maintain water levels on the ridge through no net change in ground water withdrawals.

Aerial and Vertical Discretization

A requirement of most computer modeling codes is that the system being simulated must be divided into smaller, more character consistent parts. The process is called discretization and occurs on both an aerial and vertical basis. In the case of a MODFLOW simulation, the discretization occurs in cubes or cells and can be of varying sizes. The aquifer parameters of each of these cells is then given a single value that can be mathematically defined by a set of constants. In the Osceola and GOH county models, the aerial discretization was set at uniform one-half mile by one-half mile squares. Vertical discretization, most often called layering, was established to be consistent with the thickness of the individual aquifers. In each model, layers are created for the surficial and intermediate aquifers as well as for the upper, middle and lower portions of the Floridan aquifer for a total of 5 layers (**Figure 20**). The model discretization is thought to have only a minimal effect on regional model simulations.

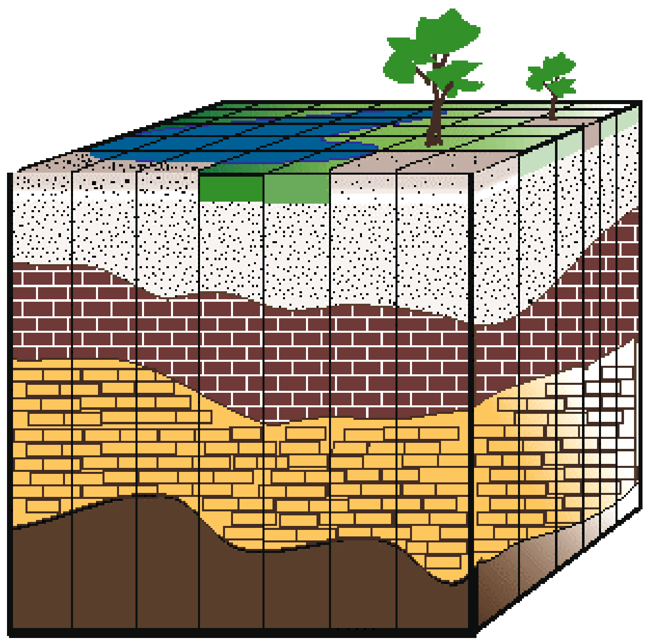

Figure 20. Example of Vertical and Aerial Discretization.

Aquifer Properties

Aquifer properties are variables that define a given characteristic of that aquifer. These variables change from location to location, but do not generally change over time. Examples of aquifer properties are hydraulic conductivity and aquifer storage. These variables define how an aquifer system will react when placed under stress. In modeling the system, an attempt is made to acquire as much information as possible about aquifer properties to assist in model development. Where this information in not available, the modeler attempts to estimate these parameters as part of the calibration process. Information regarding the aquifer parameters for the Upper Floridan aquifer is adequate within the basin. Information regarding the surficial, intermediate, middle Floridan, and Lower Floridan aquifers is less abundant in the KB Planning Area. Appendix H includes a discussion of the aquifer information used as part of the modeling efforts.

Model Calibration

After initial construction of the model, a calibration process of adjusting the parameters of the numerical model so that the model responds similarly to the physical system was made. Calibration is accomplished by finding a set of parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field measured values within an acceptable range of error. Both the Osceola County and GOH models were calibrated to steady-state or long-term average conditions. Steady-state conditions also presume that no changes in stress rates occur during that time. A trial and error method was applied in calibration of these two models.

Calibration was defined as being achieved when the water level were simulated within the calibration target. A calibration target is defined as a calibration value and its associated range. Basic statistics, including the standard deviation and variance, were estimated for each monitoring well to determine the target. In most cases, the standard deviation and variance were relatively small. This infers that there is little deviation from the mean water level.

In order to measure the success of the calibration, the model results were compared to the actual water levels obtained from the monitoring well network. The monitoring network of roughly 50 wells for each model were distributed throughout the study areas. Water levels from the wells were obtained on a monthly basis for a majority of the wells. Layer 3, the Upper Floridan aquifer, was calibrated using water levels.

In addition to examining the water levels, the calibration procedure also examines the vertical flow (recharge/discharge) between the Upper Floridan aquifer and the SAS, and the model budget. A comparison was made between the model calibrated recharge/ discharge distribution and that of the published values (see **Plate 3**). Appendix H includes the details of model calibration for each model.

Presentation of Results

In preparing the presentation of the modeling results, it was necessary to combine the output of the three different modeling efforts. This was accomplished through the use of the GIS system. During the construction of the Osceola County and GOH models, nodal locations were carefully selected so the model grids align geographically. During this process, each center node was georeferenced. The data output form these models were then combined and the surface regridded. Results of the remaining model, the USGS Metro model (1997) were interpreted from the publications and were used to provide guidance on extending the drawdown contours produced by the Osceola County model into the northernmost four miles of the basin. The interpreted points were also included into the regridded dataset and the information was then contoured. Possible errors associated with this process include small math errors cased by the recontouring process and the interpretation of the USGS model results. Errors associated with this process are anticipated to be small and are located in the northern tip of the basin.

SURFACE WATER MANAGEMENT ASSESSMENT

Lake Istokpoga-Indian Prairie Basin

Within Glades and Highlands counties, surface water has historically been used as the primary source of water. Agriculture within these two counties is highly dependent upon surface water from Lake Istokpoga and the associated Indian Prairie Basin canal system to meet its supply needs. During the mid-1980s, the District was forced to put in place water use restrictions limiting the use of surface water. Prior to this period water levels in the canal system leading from Lake Istokpoga were falling below levels where the existing pumps were able to withdraw water. Several corrective actions were taken in the late 1980s and early 1990s to prevent the further occurrence of similar problems during drought periods. The actions taken at that time appear to have corrected the water shortage problem, but no additional surface water use has been permitted in this basin since that time. As part of this planning effort, an analysis of the water availability from Lake Istokpoga and the Indian Prairie canal system was undertaken as part of the overall evaluation of the needs and sources in the basin.

The analysis of surface water availability included an assessment of the water released under the current regulatory operation through the primary release structures of S-71, S-72, and S-84. This approach involved the reviewed 20 years of flow records on these and other structures and 60 years of rainfall information to determine an estimated discharge from the basin under a 1-in-10 drought condition. The estimate for current structure releases under a 1-in-10 drought was identified as the first source of water in meeting the projected basin demand.

A budget approach was applied to determine the potential available supply of water that is in storage above the minimum operating schedule in Lake Istokpoga during a 1-10 drought event. The analysis presumes that the minimum operation schedule for Lake Istokpoga is defined as the level below which harm to the water resources is projected to occur. The details of this analysis can be found in Appendix I.

Lake Okeechobee Analysis

The use of additional water from Lake Okeechobee to supply the projected needs for the Indian Prairie Basin was made using the South Florida Water Management Model (SFWMM). The SFWMM is a regional-scale computer model that simulates the hydrology and the management of the surface water resources system from Lake Okeechobee to Florida Bay. It covers an area of 7,600 square miles using a mesh of 2 mile x 2 mile cells. In addition, the model includes inflows from the Kissimmee River, discharges and withdrawals from the Istokpoga and Indian Prairie Basin, and runoff and demands in the Caloosahatchee River and St. Lucie canal basins.

The model simulates the major components of the hydrologic cycle in South Florida including rainfall, evapotranspiration, infiltration, overland and ground water flow, canal flow, canal-ground water seepage, levee seepage, and ground water pumping.

The model incorporates current or proposed water management control structures and current or proposed operational rules. The ability to simulate water shortage policies affecting urban, agricultural, and environmental water uses in South Florida is a major strength of this model.

The SFWMM simulates hydrology on a daily basis using climatic data for the 1965-1995 period which includes many droughts and wet periods. The model has been calibrated and verified using water level and discharge measurements at hundreds of locations distributed throughout the region within the model boundaries. Technical staffs of many federal/state/local agencies and public/private interest groups have accepted the SFWMM as the best available tool for analyzing regional-scale structural and/or operational changes to the complex water management system in South Florida.

Projected surface water demands from each of the District's four planning areas as well as consideration of the components identified in the Restudy and minimum level for Lake Okeechobee were incorporated into simulations of the model. As part of these simulations, requests for additional use from the Lake Istokpoga/Indian Prairie Basin were made along with the other components listed above.

Kissimmee River Evaluation

An analysis of the availability of water from the Kissimmee River and its tributaries was not performed as part of this planning effort. The Kissimmee River is currently undergoing efforts to restore portions of its original flow and flood control functions as part of the Kissimmee River Restoration Project. This is a major effort and a high priority for the District. As part of this project, an analysis of the river’s historic flow conditions was performed. Results of the analysis suggest that the river and its supporting systems will be operating at a deficit to meet its full restoration goals (Toth, 1985). It is therefore believed at this time that additional water use from the river and supporting systems above the S-65E Structure is not a viable regional water resource option. This does not preclude the use of the river and its support system from water use permitting.

MODEL APPLICATIONS

Ground water models and surface water management assessments were used to evaluate the effects of anticipated changes in demand and water management practices on the water resources of the KB Planning Area. The results of these analyses were then used to assess whether the projected water use would cause harm to occur with regards to the defined resource protection criteria. The following sections discuss an overview of the methods employed in applying the individual resource protection criteria to the ground water and surface water analysis results.

Wetlands Vulnerability Mapping

One of the resource protection criteria proposed by the advisory committee is the protection of wetlands. The District's Basis of Review for Water Use Permit Applications (BOR) requires that withdrawals of water must not cause harm to environmental features sensitive to magnitude, seasonal timing and duration of inundation. Maintaining appropriate wetland hydrology (water levels and hydroperiod) is generally accepted as the most critical factor in maintaining a viable wetland ecosystem (Duever, 1988; Mitch and Gosselink, 1986; Erwin, 1991). Water use inducing drawdowns under wetlands, may potentially affect water levels, hydroperiod, and the aerial extent of the wetlands. The guideline currently used for Consumptive Use Permitting (CUP) evaluates the potential for harm to wetland environments is that: Ground water levels changes in the surficial aquifer after a withdrawal of the maximum recommended allocation for 90 days with no recharge are less than one foot at the edge of the wetlands for more than one month during any drought event that occurs as frequently as once every 10 years.

Due to the assumptions used in the ground water modeling tools developed, the direct calculation of the change in water table conditions was not possible. Instead, the Wetlands Vulnerability Analysis (WVA) was developed to approach the issue of wetland drawdown by assessing those factors that may influence a change in water levels within the wetland aquifer. The goal of this analysis is to identify areas where the combination of factors combine producing zones that are more susceptible to wetland harm as a result of ground water withdrawals. The factors included in the analysis are: the ability of water to move vertically thought the intermediate aquifer, location of wetland features, and the change in potentiometric head within the Upper Floridan aquifer due to changes in water use from 1995 to 2020.

Using a Geographical Information System (GIS), data for each of the factors were spatially located and then gridded to create a mesh coverage with uniform 1,100 foot dimensions. A scoring system was applied to each of the factors involved with each of the cells within the gridded mesh receiving individual scores. The score for each factor was then combined to construct a composite map showing areas of highest, moderate and lowest potential for reduction of water levels in the surficial aquifer. Details of the analysis can be found in Appendix J.

Water Quality Assessment

The movement of saline water was determined by the advisory committee to represent a limit on the amount of ground water that could be withdrawn without causing harm. The approach taken to address this issue involved mapping the existing location of the known poorer water quality areas within the Upper Floridan aquifer and comparing that information to the projected change in Floridan aquifer levels resulting from increased water use from 1995 and 2020 (1-in-10).

In instances where the saline water and fresh water zones are in close proximity, the relationship of their position to one another can be defined, in part, by the density between the two fluids and the pressure head at different points in the aquifer. The location of this interface between the fresh and saline water conditions will shift if the pressure head for either is altered. A simplistic application of this principle is applied in this planning effort to identify the potential for movement due to the proposed future withdrawals. Areas identified as having greater than 1 foot of anticipated change in the Upper Floridan aquifer in the areas where the existing water quality is above 250 mg/L are designated as having a higher risk of having a degradation in the local water quality.

Spring Discharge Assessment

Although there are no natural springs located within the KB Planning Area, several sensitive springs are located in northern Orange County in an area called the Wekiva Basin. The SJRWMD has identified minimum flow values for eight located in this area. These minimum flows are established in rule under Chapter 40C-8, F.A.C. and are also used as constraints in their planning effort. The established minimum flow requirements are based upon the minimum water levels required to maintain vegetation along the Wekiva River and its tributaries. The USGS Metro model was applied to address this issue. This model, cooperatively developed with the SJRWMD and SFWMD, directly simulates springs discharges as a function of Floridan aquifer head levels. The USGS model provides simulations of the 2020 wet and the 2020 dry conditions. The results of both of these simulations were averaged to provide an estimate of the projected spring reductions. The average condition was used to be consistent with the criteria set forth in Chapter 40C-8, F.A.C. which is based upon long-term average flow requirements for the specified springs. The resultant average 2020 spring discharges calculated by the model were compared to those set forth in Chapter 40C-8, F.A.C., to determine compliance with this resource criteria.

Sinkhole Assessment

Sinkholes are a common occurrence in certain portions of the state where unstable geologic and fluctuating hydrologic conditions work together to cause potentially dangerous forms of land subsidence. In certain instances, the conditions that lead to the formation of sinkholes can be enhanced if the hydrostatic head difference between the surficial and Floridan aquifers is significantly increased. Although a relationship between aquifer drawdown in the Floridan aquifer and the rapid formation of sinkholes has been documented in areas where the overburden is relatively thin, the degree to which these two factors are related is less defined. Two studies, one completed by the USGS and another by the Florida Sinkhole Research Institute (FSRI, University of Central Florida), described the soil conditions in Central Florida in relationship to the formation of sinkholes. These studies identify the factors involved in sinkhole development and the location where the combination of geologic factors result in the most frequent development of a specified type of sinkhole. Southwest Orange and Northeast Osceola Counties are identified as having areas were the occurrence of sinkholes are most numerous. The FSRI report also describes an effort to correlate historic Floridan aquifer levels and the frequency of sinkhole occurrence.

As part of this planning effort, maps prepared by the USGS and the FSRI were compared to the drawdown projected to occur within the Upper Floridan aquifer. Those locations expected to show the greatest change in water levels and being identified as having geologic conditions making them more susceptible to the formation of sinkholes were identified as having increased risk to possible sinkhole formation.

Impacts to Lakes Levels

Concerns over the levels of lakes within the KB Planning Area as a result of continued surface and ground water withdrawals was identified by the advisory committee as a resource limitation. With the exception of lakes like the Butler Chain of Lakes in Southwest Orange County, most of the major lakes within the KB Planning Area are on a regulation schedule. It is the presumption of this plan that the possible impacts from water use withdrawals to lake levels on lakes that have a regulation schedule would be minor compared to those changes to the lake levels resulting from the regulation schedule. For this planning level effort, lake levels for non-regulated lakes were presumed to be equally affected by Floridan aquifer water level changes as the wetland areas surrounding the lake. Under this presumption, the possible impacts to alteration of lake levels of non-regulated lakes were addressed as part of the wetland vulnerability mapping project previously discussed.

As an additional concern, the advisory committee identified several lakes along the Lake Wales Ridge that needed to be evaluated for possible lake level impacts due to withdrawals occurring within the KB Planning Area. These lakes are located within the SWFWMD and have been identified by that District as having trouble meeting historic water levels. The SWFWMD staff has related these problems to decreases in water levels in the ground water system, specifically the Floridan aquifer. As part of their own planning and recovery efforts, the SWFWMD is making efforts to prevent further declines in the Floridan aquifer levels beneath the ridge area. This SWFWMD goal has been translated into the SFWMD planning process as a limiting criteria of no more than one foot change in Floridan aquifer levels at the boundary line between the two Districts. The ground water modeling completed as part of this planning effort addresses this concern.